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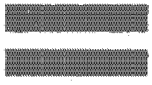

December 1, 2005

Dr. Carl Hershner
Chair, STAC
VA Institute of Marine Science
Gloucester Point, VA 23062

Dear Dr. Hershner:
This is to provide to the Scientific and Technical Advisory Committee the Model Subcommittee's response to the 2005 STAC Watershed Model Review. We thank STAC and the Watershed Model Review Team for an insightful and thoughtful review. We believe that this review will help us improve our ability to serve our principle customers, the State and Federal decision-makers of the CBP.

Overall Comments
The STAC sponsored review has had a direct effect on recent decisions by the partners planning for the 2010 revision of the existing nutrient and sediment cap load allocations. As a result of significant discussions among the jurisdictional and EPA partners at the recent September 21-22, 2005 Reevaluation Workshop, the partners have built in a 20-month period between Modeling Subcommittee release of the initial calibrated Phase 5 Watershed Model, scheduled for April 2006, and final partner approval of the model for application in support of management decision making scheduled for December 2007. Part of the rationale for this overall decision was the partners' desire to build in more time to enable the Modeling Subcommittee to respond more fully to the near-term, Phase 5 model oriented recommendations from the independent peer review panel.

The Modeling Subcommittee has been charged with the responsibility for approving the Phase 5 Watershed Model for scoping scenarios by April 2006. In the months that follow scoping model approval, the jurisdictions will be strongly encouraged to review the extensive calibration results in more detail. Sensitivity scenarios will be run at the partners' request to more fully understand the model and how it is likely to respond under the intended management scenarios scheduled to be run starting in January 2008. During this time, the Modeling Subcommittee and Phase 5 Modeling Team will continue to pursue work in response to the panel's recommendations. The partners set June 2007 as the cut-off date for the jurisdictions to request Phase 5 modifications. After completing the modifications and upon approval of the Modeling Subcommittee, the Phase 5 Watershed Model will be presented for partners' approval for management application by December 2007.

The Modeling Subcommittee will provide STAC with periodic updates on our continued responses to the recommendations continued within the panel's report. The recommendations by the panel directed toward future watershed model refinements beyond the deadlines and schedule of the Phase 5 model will be raised for discussion by the larger Bay region community at the 2006 STAC

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sponsored Chesapeake Bay modeling workshop to be chaired by Larry Sanford.

Nutrient Calibration

The review occurred before the nutrient and sediment calibrations had been implemented and so the reviewers were not able to assess the ability of the Watershed Model to match observed water quality data. They state that the "reproduction of nutrient concentrations is an important goal for diagnosing the model's performance." In light of this, we request that STAC undertake a post-calibration review to be completed by mid-2007

Comparison with other large-scale efforts

The reviewers suggest comparisons with other large-scale modeling efforts, such as the large-scale national SWAT model. As suggested, we will compare methods and model results with the AGNPS and SWAT models now being developed for the Choptank watershed, and will compare Phase 5 everywhere in its domain with the National SWAT model. These comparisons will be made when the SWAT and AGNPS models become available (estimated completion in 2007).

Consistent with the approach suggested by the review we will make immediate and direct use of the national and Chesapeake Bay SPARROW models (USGS), as well as a specially designed land-use specific Chesapeake Bay SPARROW run, to help us set calibration targets for different land uses. The SPARROW models may also be used as direct input or calibration targets for coefficients determining sub-grid delivery ratios if judged to be applicable and appropriate.

Need for adaptive management framework

The Chesapeake Bay Program (CBP) managers and modelers have used adaptive management concepts and will continue to do so as suggested by the review. Throughout the two decade history of the CBP, management goals have been refined as models, monitoring networks, and research generate better estimates of the relationships between forcing functions and ecosystem response. This is a two-way street, and the models, monitoring networks, and research have likewise been refined in response to management needs. In addition, new research and analyses of monitoring data are routinely integrated with models for model validation and refinement. An example of adaptive management suggested by the review is the recent use of both the Watershed Model and SPARROW to select additional monitoring sites in the non-tidal network. As suggested by the review, we will continue to look for ways to apply and expand adaptive management practices.

Need for formal uncertainty analysis

Uncertainty analysis requires automated calibration and data analysis methods, as well as large computing resources. Many of the techniques for large-scale Watershed Model uncertainty analysis were recently developed and are areas of ongoing and active research. While we've been unable to provide estimates of uncertainty in the past due to theoretical and practical constraints, we believe these constraints have decreased with the new tools now available and we welcome the opportunity to pursue this analysis as suggested by the review. We found the suggestions in this section of the review to be useful and specific, and plan to begin the uncertainty analysis at the close of model calibration in April 2007.

Parameter and input uncertainty analyses can be addressed through modifications of Monte Carlo methods. We are already developing the automated calibration techniques necessary for this work. The review suggests additional data sets of internal storage variables be used to constrain the

calibration. We will look for opportunities to incorporate these data as they come available. One promising data set of this type is the near-daily MODIS-generated NDVI, with is loosely related to the biomass of plants, which is a state variable in HSPF.

The review suggests evaluating unaccounted for hydrologic variability by evaluating the performance of the Watershed Model seasonally and during hydrologic extremes. Consistent with this review suggestion is the approach we've taken in the current hydrology calibration, which uses analyses of high and low flows as specific measures of performance linked to particular model parameters. Scores for the performance of the model in hydrologic extremes are recorded as well as the performance overall. To the fullest extent possible, we will use these same types of measures in the calibration of sediment and nutrients as suggested by the review.

We agree with the reviewers that statistical distributions of outcomes as expressed by the cumulative frequency distributions are more important than fitting the precise timing of events given the input data uncertainty. Currently, our judgment of calibration quality comes mainly from such statistics and this will continue to be an important feature of the automated calibration and uncertainty analysis.

The second part, of simplified model development, is underway as part of the requirements of a CBP project known as the 'Vortex'. The 'Vortex' integrates input and output information for the Watershed Model and is inherently a 'simplified model' that is much easier and faster to use. The 'Vortex' is nearly complete for the Phase 4.3 Model and will be updated for Phase 5 as part of the completed model.

Timeline for implementation of review recommendations

The timeline for implementation of review recommendations are sorted into three categories: currently adopted actions, near-term actions, and long-term actions

1. Recommendations that the CBP has currently adopted:
   - 1.1. **Adaptive Management** has been part of the CBP management and scientific strategies for many years. Additional emphasis is being placed in this area.
   - 1.2. **Uncertainty Analysis**. The current calibration strategy is intentionally designed to support uncertainty analysis.
   - 1.3. **Integration of Modeling and Monitoring** is formally accomplished during the calibration exercise to the extent that the model is optimized to reproduce monitoring data. The Watershed Model was also recently used in the process of selecting new monitoring stations.
   - 1.4. **Evaluation of Precipitation** is ongoing. As we finalize the precipitation model, we test versions for their ability to generate high model efficiencies.
2. Recommendations to be adopted in the near-term:
   - 2.1. **Dynamic BMP Efficiencies** that react to the hydrologic state will be incorporated before January 2006
   - 2.2. Formal **uncertainty analysis** will be pursued starting with the approval of the Phase 5 calibration for scoping scenarios, tentatively scheduled for April 2006.
   - 2.3. **Comparison with other large-scale modeling efforts** will occur in 2007-2008 as Phase 5 and the national SWAT model are completed. We will compare them as part of the model structure uncertainty analysis
   - 2.4. The **Integration of Modeling and Monitoring** for the purposes of selecting new monitoring sites will depend on the formal uncertainty analysis. The capability will be available for the next phase of monitoring network development. (date undetermined)
   - 2.5. **Scaling from Smaller Basins** will be accomplished in the near term by using information on coastal plain loads and BMPs generated by the USDA-ARS CEEP modeling in the Choptank. (when small basin models are available in 2007)
   - 2.6. **Looking for Emergent Properties of the Model** is part of the testing that we conduct after calibration and before approval for use in management decisions. This process is scheduled to start in April, 2006
   - 2.7. **Develop Simplified Models.** The 'Vortex' project, which is scheduled to be operational for Phase 5 by April, 2006 will be used as a simplified model in that it calculates model inputs and can predict output based on **Emergent Properties**
3. Recommendations that will be adopted in future years or as part of a new model development phase
   - 3.1. **Integration of Modeling and Monitoring** within the structure of a Bayesian analysis is a subject of active research and, while this type of analysis would be very useful, we cannot guarantee that this can be accomplished effectively with the Phase 5 model schedule and deadlines.

3.2. **Scaling from Smaller Basin Modeling Studies** will continue if and when large hydrologic network studies like CLEANER or CUASHI are completed. We will also integrate information gained from MDE using Phase 5 on small scale exercises.

3.3. **Alternative River models.** Phase 5 is structured so that the substitution of a separate river model could be accomplished in a straightforward manner, however the current deadlines do not allow for this type of study.

The Modeling Subcommittee again thanks the reviewers for the application of their knowledge and experience in the Phase 5 Watershed Model review. We look forward to working with the regional model review group as we continue to calibrate and apply the Phase 5 Watershed Model.

Sincerely,

James R. Collier
Chair, Modeling Subcommittee

cc: K. Sellner
L. Linker
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